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THE RELATIONSHIP BETWEEN MUSICAL AUDIATION AND MATHEMATICAL PERFORMANCE IN SECOND GRADE CHILDREN IN PRIMARY SCHOOL

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Abstract:
This research attempts to determine the relationship between musical Audiation and mathematical performance in second grade children. 36 children (N = 36) participated in the survey, 15 of whom were boys (N = 15) and 21 were girls (N = 21). For the assessment of musical audiation, Gordon's "Elementary Musical Audiation Measures" (Stamou, Schmidt & Humphreys, 2006) and a mathematical performance appraisal tool for second grade students were used by the researchers. The results showed a strong relationship between the overall performance of the musical Audiation and the mathematical performance, while also being a significant predictive factor. According to the results, the gender factor does not seem to be of any importance in the students' performance.

Keywords: musical audiation, elementary musical audiation measurements, mathematical performance, prediction of mathematical performance

1. Introduction

The relationship between music and mathematics has long been examined. Over the last four decades there have been researches that highlight specific aspects of this relationship, what could connect these two seemingly different areas. Does music improve mathematical performance, and if so, why? The purpose of this study is to investigate whether performance in the musical audiation test is linked to mathematical performance and whether it can be a predictive factor in elementary school students.

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2. Literature Review

2.1. Intelligence

Conceptual identification

The concept of intelligence has been defined in many ways by experts and is perhaps the most controversial subject of psychology because "*Intelligence is not only an academic subject, but a subject with profound political implications as to whether it is acquired through learning and experience or whether it is a permanent, inheritable trait"* (Polychronopoulou, 2001).

We perceive intelligence as the general ability of the individual to adapt successfully to environmental conditions and thought as its expression (Motti-Stephanidi, 1999; Snow, Kyllonen & Marshalek, 1984; Carpenter et al., 1990).

Theories related to the nature of intelligence are classified in two categories. a) The One factor/UNI factor theory, according to which intelligence consists of a factor "g", mainly hereditary that defines all its functions. b) Multifactorial theories? (Guilford, 1967; Spearman, 1904; Sternberg, 1985; Thurstone, 1938; Vernon 1963, 1969; Maranon & Pueyo, 2000). The most recent of these is the Sternberg's triarchic theory (1985) that attempts to explain the unusual (charismatic and low) intelligence shown in children, but also to study and interpret the inadequacy of various intelligence tests. Another theory is the theory of the eight types of intelligence by Gardner (Gardner, 1983). Based on this theory, the existence of a general factor "g" is not acceptable. There is not only one kind of intelligence, but eight, which are autonomous and are: linguistic, logical, musical, spatial, physical, interpersonal, intrapersonal, and finally naturalistic intelligence (Gardner, Gardner, 1999; Silver, Strong, & Perini, 1997; Visser, Ashton, & Vernon, 2006). Everyone has these skills. The difference lies in the different degree of possession and development of each skill and the way in which they are combined.

2.2. Relationship of music, intelligence, academic and mathematical performance.

Intelligence is a powerful predictor of school performance (Deary et al., 2007; Gut, Reimann, & Grob, 2012, 2013; Roth et al., 2015). Mathematical performance and music composition are also closely related to intelligence. In particular, mathematics is regarded by a large part of the student population as a particularly difficult subject, which requires a substantial amount of mental work. Research shows a strong correlation between cognitive performance, mathematical performance (Deary, Strand, Smith, Fernandes, 2007; Roth, Becker, Romeyke, Schäfer, Domnick & Spinath, 2015) and deductive reasoning, ie reasoning related to the perception of mathematical relations, drawing conclusions and mathematical knowledge. Reasoning ability is the main feature of fluid intelligence and is closely related to mathematics (Floyd, Evans & McGrew, 2003; Fuchs et al., 2006). Fluid intelligence, defined as the ability to use the necessary mental functions to solve new problems and situations (Horn and Cattell, 1967), is hereditary and develops during the first two decades of a person's life. The correlation between cognitive ability and mathematical performance is not only positive but also predictive performance in intelligence tests can predict mathematical performance (Neukrug & Fawcett, 2015) even three years later (Gygi, Hagmann-von Arx, Schweizer & Grob, 2017). An equally strong connection seems to exist between mathematics and visual - spatial ability. Several studies have emphasized the ability of children to spatial planning as a key factor in their mathematical development (Battista & Clements, 1996; Battista et al., 1998; Mulligan, Prescott & Mitchelmore 2004; Mulligan et al., 2006b, 2008) and understanding of numerical relationships.

2.3. Intelligence and music relationships

Music and math are closely linked. Children are constantly trying to organize their world by discovering different motifs and creating structures (Gopnik et al., 2004). Mathematics is an activity of organizing and solving problems. The organization of the problem should be done in accordance with mathematical models in order to find solutions (Freudenthal, 1991). Music also requires the organization of information and, like a mathematician, the musician looks for patterns, creates structures and solves problems (Pogonowski, 1987).

The most important relationships between music and mathematics were related to spatial perception, temporal reasoning and spatio-temporal logic (Hetland, 2000a, b). A study (Rauscher, Shaw, Ky, 1993) investigated the relationship between music and spatial activities in children aged 3 to 4 years and 9 months. The results showed a significant difference in performance in the object assembly activity (subscale of the wisc iii test) for the test group in relation to the control group.

Students' participation in music and math activities requires high level of thinking and increases participation and motivation (Cranmore & Tunks, 2015). Music, as well as mathematics is associated with increased intelligence, high test scores and high academic performance. An extensive research has been carried out on how music can increase intelligence by positively impacting the person listening to music (Rauscher et al., 1993; Dege, Kubicek, & Schwarzer, 2011; Moreno, Bialystok, Barac, Schellenberg, Cepeda, & Amp; Chau, 2011). The most popular research in this area is the so-called Mozart effect. In this research (Rauscher, Shaw, Levine, Ky & Wright, 1994) the sample was divided into three groups. One group heard Mozart's Sonar K. 448 at D Major for 10 minutes, the second group listened to relaxation instructions, and the third group had no interference. Then, they were subjected to spatial reasoning tests with the Stanford-Binet scale. The results showed that the group listening to classical music achieved 8-9 IQ degrees higher than the other groups. The findings show a causal relationship between music and cognitive performance and specifically in spatial-temporal reasoning.

Music seems to increase the overall index of intelligence in relation to arts such as theater (Schellenberg, 2004). In this study, 144 children were divided into four groups. One received voice classes, the second piano, the third theater lessons, and the fourth, which was the control group, was subjected to no special intervention. The results showed that the increase in the intelligence index for the group receiving piano lessons was 7 points, for the vocal group 7.5 points, for the theater group 5 points and finally for the control group 4 points. The results show that listening to music does not affect intelligence very much, but active engagement with music in the form of musical lessons makes a positive contribution to intelligence and cognitive functions, although it is important to note that these results are not always repeated.

2.4. Music, Intelligence, and Academic Performance

The relationship between music and academic performance was investigated quite early (Hedden, 1982). This study examined the relationship between musical performance and academic performance (along with four other prognostic factors, such as gender). Using a multiple regression analysis for data collected from fifth and sixth grade students, the research concluded that musical performance was the best predictor for academic performance (R2 = / 25, n = / 79 for one school and R2 = / 41; n = / 65 for the other school). Musical performance, as well as mathematical performance, allows the prediction of academic performance. Schellenberg (2006) reports a positive correlation between music lessons and IQ in children aged 6-11. Research has shown that teaching music lessons in childhood affects both academic performance and IQ during adulthood. In general, a major debate is under way as to whether musical education leads to an increase in specific skills and if it could lead to a worldwide increase in cognitive abilities as measured by general mental quotients. Forgeard, Winner, Norton & Schlaug, (2008) found that the practice of a musical instrument increases performance in the Raven's Matrices test, which is free from the language factor, which may suggest that non-verbal reasoning skills are better developed in children when they receive musical training.

Research shows a significant positive relationship between music and mathematical achievements. There are several results indicating the contribution of music to the development of mathematical skills such as spatial competence, sequence, formatting, counting, one-to-one matching and problem solving (Geist, Geist, & Kuznik, 2012; Gruhn & Rauscher, 2002; Sposet, 2008). A lot of evidence showcases the positive effects of music on mathematical ability. Most researches show that when children are educated in music from an early age, they tend to improve their math skills. Indeed, certain aspects of music affect mathematical abilities to a great extent. Studies conducted mainly in young children show that their academic performance is increased after a certain period of musical education and training (Hopkins, 2003). In another research (Gouzouasis, Guhn, Kishor, 2007), musical activities like band and choir participation, strings, music composition and their impact on academic performance (mathematics, language course, biology) were discussed. The results showed that the strongest correlation was between mathematics and musical composition. In another study (Gardiner, 1996), students of the first grades received music teaching with emphasis on the development of scheduling skills, succession and musical games that included rhythm and tone. After a period of six months, mathematical performance was greatly improved in the students of the groups that received the standard music teaching. In another rhythm research, children under the age of 8 who have undergone 6 months of musical education have shown increased accuracy in small differences in acoustic discrimination.

Musical education positively affects learning performance. In addition, research shows that studying music also increases mathematical performance. Identifying more aspects of this relationship can benefit students of all levels and abilities.

2.5. The Aim of Current Study

As stated, key learning processes of mathematics and music have many common features. Indeed, certain aspects of music such as rhythm and tone and basic elements of musical acuity affect mathematical ability to a large extent (Gardiner, 1996). Musical audiation as a term was mentioned by Gordon and is defined as the ability of a person to feel the melodies or rhythms he has heard (Papazacharis, 1999). The individual is able to perceive and recognize the changes in tone, rhythm, content and performer of the musical ensemble (Anvari, Trainor, Woodside, & Levy, 2002).

The purpose of this research is to investigate the possible relationship between musical acuity and mathematical performance in primary school students. Based on the above theoretical and research data, we formulated the following research questions:

- Whether and to what extent, the musical audiation of second grade students is related to mathematical performance.
- Whether the musical audiation of second grad students is a predictive factor of mathematical performance.

2.5.1 The Importance of the Research

This study aims to identify factors that can provide useful information on the mathematical performance of elementary school students. The early detection of constraining math difficulties during early primary school years is particularly important since rapid and timely intervention can be decisive. Also as any original study, the current one aims to pave the way towards further in-depth research in this field.

3. Material and Methods

3.1. Participants

The study included thirty-six second grade Greek students (N = 36), twenty-one girls (N = 21) and fifteen boys (N = 15). Research is an extremely useful process since it allows the acquisition and disclosure of knowledge. But it must respect the right of participants to self-determination, privacy and dignity. These principles have been fully respected during this study. So the students' parents were briefed and their consensus was ensured. They were assured that no information related to student identity and personal information would be published. Additionally, care will be taken to ensure that no correlation may occur, which would potentially lead to the disclosure of the identity of the subjects or the disclosure of sensitive personal data.

3.2. Experimental Plan and Process

The experimental process was designed to test the relationship between musical audiation and mathematical performance as well as the probability of it being a predictive factor of student performance in mathematics. The intervention was implemented in two phases. During the first phase, the level of students' music listening ability was evaluated. The second phase included the evaluation of mathematical performance. After the completion of the research program, performance scores were compared with musical audiation and mathematical performance to identify correlations and draw conclusions.

3.3. Measurements

To measure musical audiation, Gordon's Primary Measures of Music Audiation (PMMA) test was used for children aged five to eight years. The test consists of two tests, one tonic and one rhythmic (Stamou, Schmidt & Humphreys, 2006). The test coefficients for the second grade are 0.87 for tonic, 0.66 for rhythmic, and 0.77 overall. The participation of children in the test does not require any previous music experience, as it is an easy and simple process with comprehensible and clear instructions. The duration of each test is estimated at approximately 12 minutes.

The tonic part involves listening to 40 recorded pairs of melodic motifs and the student is asked to sketch through pictures in the answer sheet if they are the same or different. In the answer sheet for each pair at the bottom of the image, there are two identical boxes. The first contains two identical sketches of smiling faces, while the second contains two different sketches, a smiling and a sad face. If the student considers the motifs he heard to be the same, he marks a circle in the box with the same two faces, and if he considers the two patterns to be different, he rounds the box containing the two different faces. The rhythmic part consists of 40 pairs of recorded rhythmic motifs and, like in the tonic part, the student through the same process is called upon to judge whether they are the same or different. The answer sheet follows the same pattern for choosing the right answer.

Following the completion of the PMMA test, three scores (indicators) are obtained. One for the tonic part, one for the rhythmic part and a total one, which is a sum of the other two (tonic and rhythmic). The number of correct answers in the tonal part is characterized as tonic score and is an indicator of the child's tonic audiation. Accordingly, the number of correct answers in the rhythmic part is characterized as a rhythmic score and is an indicator of the child's rhythmic audiation. The sum of these two indices is the overall score and is considered to be the indicator of the overall musical audiation of the child (Stamou, Schmidt & Humphreys, 2006). The initial grades of each test scale are converted into standard grades based on which the students' performance is calculated on a percentile scale.

For the assessment of mathematical performance, it was preferable to build an assessment criterion based on second grade curriculum. This specific criterion was tried on 34 students in the second (B) grade. To test the reliability, the same test (retest) was used on the same individuals. The results showed quite high credibility (a = 0.87). In order to determine the validity of the conceptual construction of the criterion, its following characteristics were examined.

1) Content validity. Criteria queries are valid content-wise as they come from the second grade curriculum and are chosen to cover the basic features of each unit under consideration.
2) Criterion validity. This aspect is about linking the criterion with another, reliable criterion. The criterion chosen was California Standards Test Grade 2 (Los Angeles County Office of Education).

The correlation of the two criteria has been quite satisfactory and ranged from 0.75 to 0.94. In addition to the validity of the criterion, the teacher of each class was asked to evaluate his or her students in mathematical competence and rank them by placing first the student with the highest and last the one with the lowest performance. The degree of correlation of the students' ranking based on the criterion of mathematical performance and their ranking based on the teacher's ranking was high (from 0.71 to 0.96). Another important fact was that the teachers had been teaching the same class for the second consecutive year.

4. Results and Discussion

The results were processed using SPSS 21 for Windows. Table 1 gives a description of the sample. The sample consists of 36 primary school students (N = 36), of which 15 are boys (N = 15) and 21 are girls (N = 21). Independent variable t was used to calculate the averages of the two sets of the sample (boys, girls) to check for potential performance differences in the areas tested. Table 1 shows the performance in tonic (ton), rhythm (Ryth), total and math (permath) test.

Table 1: Descriptive Statistics

Variables	**Sex**	**N**	**M**	**SD**
Tonic	Male	15	28,20	7,94
	Female	21	27,52	8,09
Rhythm	Male	15	25,73	6,65
	Female	21	27,14	7,09
Total	Male	15	53,93	13,37
	Female	21	54,66	13,95
Permath	Male	15	96,13	30,92
	Female	21	101,42	28,34

The degree of correlation between the variables was then investigated. The results of the correlation test showed a positive correlation between the variables (table 2).

Table 2: Correlation between variables

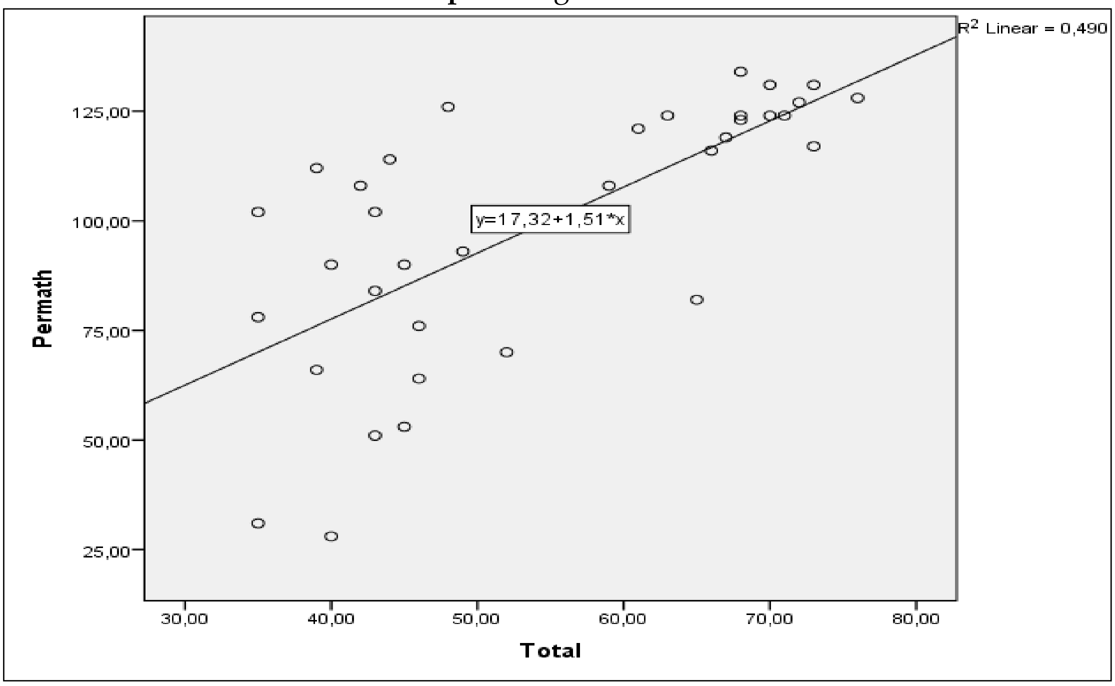
Measurements variables	1	2	3	4
Tonic	-			
Rhythm	,674**	-		
Total	,927**	,902**	-	
Permath	,625**	,659**	,700**	-
*= p< .01, **= p< .001				

Regression analysis was then used to test the extent in which the independent variables (tonality-tone performance, rhythm performance test, total performance) positively contribute to the dependent variable (which is mathematical performance (Permath)) and to what extent this relationship can be generalized. Results of the regression analysis are reported in the following tables (3)

Table 3: Regression analysis

Variable	**B**	**SEB**	**b**
Total	1,507	,264	,700**
R^2 = ,490, $F_{(1,34)}$ = 32,62, p<,000			

Graph 1: Regression line



5. Recommendations

The sample consisted of 36 students. This is constitutes an important limitation of this research. For this reason, we estimate that a sample of a larger range and size is required. Despite this limitation, this study is highly important.

6. Conclusion

A total of 36 primary school students (N = 36) participated in this survey. Of these students 15 (N = 15) were boys and 21 (N = 21) were girls (Table 1). The sample distribution was normal. Next, the correlation of the variables with each other was tested, to see if they are related. The results (Table 2) showed high correlations between all four variables (Ton * Ryth =, 674: Ton * Total =, 927: Ton * Permath =, 625). The averages of the two sample sets (boys, girls) were compared to identify potential differences in performance in the areas affected by the four variables (tonic test performance, auditory performance, overall test performance, mathematical performance). The results showed that no statistically significant difference in performance was observed between boys and girls in the tonic test t (df 34) =, 249. Out of the averages, boys had a higher average (28.20) SD 7.94 than girls (27.52) SD 8.09. In the rhythm test, there was also no statistically significant performance difference between boys and girls t (df 34) = -, 603. Out of the averages, boys had a lower average (25.73) SD 6.65 than girls (27.14) SD 7.09. In the overall musical acuity test, the performance difference observed was not statistically significant t (df 34) = -, 158. Out of the averages, boys had a lower average (53.93) SD 13.37 than girls (54.66) SD 13.95. A statistically significant performance difference between the two genders was not observed in the mathematical performance test either t (df 34) = -, 532. Regarding the averages, boys had a lower average (96.13) SD 30.92 than girls (101.42) SD 28.34.

Regression analysis was used to interpret mathematical performance (Permath) from the independent variables which were Ton, Rhythm and Total performance. The results (Table 3) show a possible relationship between total performance and mathematical performance (R =, 700a, F = 32.62 p <001). The performance in the musical audiation test (total) contributes positively to the interpretation of mathematical performance (Permath) (Beta =, 70: t = 5.71: p <0.001). The performance in the total auditory test interprets mathematical variability at 49% (R Square =, 490), which can be extended to the general population at 47.5% (Adjusted R Square, 475). F is 32,624 therefore we see a significant contribution in predicting mathematical performance. Also by observing the relative graph (graph 1) it can be seen that the regression line is tilted to the right, therefore the weighting B has a positive value (a = 17, 31 and B = 1,50). Much of the points in the spreadsheet appear to be straight and close to the regression line.

The purpose of the present study was to highlight the close relationship between PMMA and mathematical performance (Tonic - Rhythmic - Total). The results show a possible relation of total musical audiation with mathematical performance. In addition, performance in the overall musical acuity test can be a predictive factor in mathematical performance in second grade students. To date, it is known that the subjects of music and mathematics are connected. This is confirmed by the close relationship between musical audiation and mathematical performance.

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Giannis Manginas is a teacher of special education and is currently teaching at the 1st Elementary School of Filippiada, Preveza (Greece). He graduated from the National Kapodistrian University of Athens, Department of Primary Education. He has completed postgraduate studies in special education at the University of Ioannina (Greece). He specialized in the analysis of cognitive language learning and dyslexia at the University of Patras, Department of Primary Education (Greece). He also specialized in the creation of educational material for students with mild intellectual disability in the Communication and Mass Media Department of the University of Athens. He obtained a master's degree from the University of Thessaly (Greece). The graduation thesis was concerned with the teaching of mathematics to students with intellectual disabilities through innovative approaches. He obtained a master's degree in bilingual special education and training from the Department of Early Childhood Education of the University of Western Macedonia (Greece). The graduation thesis was concerned with the teaching of mathematics to students with mild intellectual disabilities through the use of new technologies. He has been an instructor of primary and secondary education teachers, during seminars organized by the Greek Institute of Education and the University of Patras. His papers on education have been published in scientific journals.

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